puscles are denoted by reference numeral **122**. They are shown schematically and greatly magnified.

[0039] The high-voltage amplifier **100** is driven by a signal IN which results in a substantial portion of the energy content of the resulting Coulomb forces to reside in a frequency range to which the Pacinian corpuscles **122** are sensitive. For humans this frequency range is between 10 Hz and 1000 Hz, preferably between 50 Hz and 500 Hz and optimally between 100 Hz and 300 Hz, such as about 240 Hz. The frequency response of the Pacinian corpuscles is further discussed in connection with FIGS. **5** and **6**.

[0040] It should be understood that, while "tactile" is frequently defined as relating to a sensation of touch or pressure, the electrosensory interface according to the present CEI, when properly dimensioned, is capable of creating a sensation of vibration to a body member even when the body member **120** does not actually touch the insulator **108** overlaying the electrode **106**. This means that unless the electrode **106** and/or insulator **108** are very rigid, the pulsating Coulomb forces between the electrode **106** and body member **120** (particularly the Pacinian corpuscles **122**) may cause some slight mechanical vibration of the electrode **106** and/or insulator **108**, but the method and apparatus according to the CEI are capable of producing the electrosensory sensation independently of such mechanical vibration.

[0041] The high-voltage amplifier and the capacitive coupling over the insulator **108** are dimensioned such that the Pacinian corpuscles or other mechanoreceptors are stimulated and an electrosensory sensation (a sensation of apparent vibration) is produced. For this, the high-voltage amplifier **100** must be capable of generating an output of several hundred volts or even several kilovolts. In practice, the alternating current driven into the body member **120** has a very small magnitude and can be further reduced by using a low-frequency alternating current.

[0042] FIG. **2** illustrates an apparatus which implements an illustrative embodiment of the present CEI. In this embodiment the high-voltage amplifier **100** is implemented as a current amplifier **102** followed by a high-voltage transformer **104**. In the embodiment shown in FIG. **2**, the secondary winding of the high-voltage transformer **104** is in a more or less flying configuration with respect to the remainder of the apparatus. The amplifier **100**, **102** is driven with a modulated signal whose components are denoted by **112** and **114**. The output of the high-voltage amplifier **100** is coupled to an electrode **106** which is insulated against galvanic contact by the insulator **108**. Reference numeral **120** generally denotes a member to be stimulated, such as a human finger. Human skin, which is denoted by reference numeral **121**, is a relatively good insulator when dry, but the CEI provides a relatively good capacitive coupling between the electrode **106** and the electrically conductive tissue underneath the skin surface **121**. Mechanoreceptors, such as the Pacinian corpuscles **122**, reside in this conductive tissue. In FIGS. **1** and **2**, the Pacinian corpuscles **122** are shown schematically and greatly magnified.

[0043] A benefit of the capacitive coupling between the electrode **106** and the electrically conductive tissue underneath the skin surface, which is known as the Corneus Layer and which contains the Pacinian corpuscles **122**, is that the capacitive coupling eliminates high local current densities to finger tissue, which would result from contact that is conductive at direct current.

[0044] It is beneficial, although not strictly necessary, to provide a grounding connection which helps to bring the subject to be stimulated, such as the user of the apparatus, closer to a well-defined (non-floating) potential with respect to the high-voltage section of the apparatus. In the embodiment shown in FIG. **2**, the grounding connection, denoted by reference numeral **210**, connects a reference point REF of the high-voltage section to a body part **222** which is different from the body part(s) **120** to be stimulated. In the embodiment shown in FIG. **2**, the reference point REF is at one end of the secondary winding of the transformer **104**, while the drive voltage for the electrode(s) **206**A, **206**B, **206**C is obtained from the opposite end of the secondary winding.

[0045] In an illustrative implementation, the apparatus is a hand-held apparatus which comprises a touch display activated by finger(s) **120**. The grounding connection **210** terminates at a grounding electrode **212**. An illustrative implementation of the grounding electrode **212** is one or more ground plates which are arranged such that they are conveniently touched one hand **222** of the user while the apparatus is manipulated by the other hand. The ground plate(s) may be positioned on the same side of the apparatus with the touch display and next to the touch display, or it/they may be positioned on adjacent or opposite side(s) from the side which comprises the touch display, depending on ergonomic considerations, for example.

[0046] In real-world apparatuses, the coupling **210** between the reference point REF and the non-stimulated body part **222** may be electrically complex.

[0047] In addition, hand-held apparatuses typically lack a solid reference potential with respect to the surroundings. Accordingly, the term "grounding connection" does not require a connection to a solid-earth ground. Instead the grounding connection means any connection which helps to decrease the potential difference between the reference potential of the apparatus and a second body member distinct from the body member(s) to be stimulated. This definition does not rule out any capacitive parallel or stray elements, so long as the grounding connection **210** helps bring the user of the apparatus, along with the non-stimulated body part **222**, to a potential which is reasonably well defined with respect to the high-voltage section of the apparatus. A capacitive grounding connection will be discussed in connection with FIG. **12**. In the present context, the reasonably well-defined potential should be understood in view of the voltage OUT which drives the electrode(s) **206**A, **206**B, **206**C. If the electrode drive voltage OUT is, say, 1000 V, a potential difference of, say, 100 V, between the user's body and the reference point REF may not be significant.

[0048] The non-capacitive coupling **210** between the reference point REF of the high-voltage section and the non-stimulated body part **222** greatly enhances the electro-sensory stimulus experienced by the stimulated body part **120**. Conversely, an equivalent electro-sensory stimulus can be achieved with a much lower voltage and/or over a thicker insulator when the non-capacitive coupling **210** is being used.

[0049] The amplifier **100**, **102** is driven with a high-frequency signal **112** which is modulated by a low-frequency signal **114** in a modulator **110**. The frequency of the low-frequency signal **114** is such that the Pacinian corpuscles, which reside in the electrically conductive tissue underneath the skin surface, are responsive to that frequency. The frequency of the high-frequency signal **112** is preferably slightly above the hearing ability of humans, such as 18 to 25 kHz,